INSTALLATION AND PRE-CERTIFICATION OF CTBT STATION IS59, HAWAII

Milton Garcés[1]
Infrasound Laboratory, University of Hawaii, Manoa
[1]Also at the University of Alaska, Fairbanks

Henry Bass
National Center for Physical Acoustics, University of Mississippi

Sponsored by the U.S. Department of Defense

Contract No.: DASG60-99-0018

ABSTRACT

The IS59 site survey took place on June 2-16, 1999. The site survey report recommended the installation of IS59 in an exceptionally quiet and well forested area in the Western side of the island of Hawaii. After the September PTS acceptance of the proposed array location, lease and land use agreements were executed and site work began on December 1999. The acceptance test for the integrated data acquisition system took place on May 15-18. On May 25, 2000, IS59 began collecting and archiving pressure data, and since June 1 the CD-1 data frames have been continuously sent to the PIDC.

The IS59 array consists of four Chaparral 5 pressure sensors deployed in a tripartite configuration with a 1.9 km aperture. Each sensor feeds into Science Horizons digitizers and authentication boxes, which are powered via ground cables from a central solar panel array. Communication cables run from the concrete vaults that house the equipment to a central site with a 120 ft mast that support the telemetry antennas above the forest line. Continuous pressure, state of health, and meteorological data is sent via radio telemetry to the Infrasound Laboratory, which will act as the central facility that archives data and routes CD frames to the IDC through a VSAT link. This paper outlines the installation and ongoing pre-certification process of the Hawaii station, and shows various signals that have been observed during its operation.

Key Words: Hawaii, certification, IS59, infrasound

OBJECTIVE

The aim of this stage of the project is to complete the installation of IS59 and streamline its operation so that it will meet the certification requirements of the CTBT International Monitoring System. An additional objective is to identify enhancements that may optimize the performance of IS59.

RESEARCH ACCOMPLISHED

Introduction

IMS infrasound array IS59 is located in the Western side of island of Hawaii, also known as the Big Island (Figure 1). The array site is completely blocked from the trade winds by Mauna Kea, Mauna Loa and Hualalai volcanoes, and thus the site is exceptionally quiet (Garces and Bass, 1999). The array (Figure 2) has a 1.9 km baseline with a central power and communication system, and each element is connected to the central area via ground cables. Data is sent via radio telemetry to the Infrasound Laboratory (ISLA), which acts as the recording facility and archives data in CSS format. The first field station began recording pressure data on May 25, 2000 at 06:34:16 UT. The array began recording pressure data on May 26 at 02:15:43 UT, and the PIDC began receiving CD-1 frames on June 1, 2000. Various regional and distant events have been recorded, and the low self-noise and high sensitivity of the hand-tuned Chaparral 5 sensors have yielded a low threshold of detection. However, spatial aliasing reduces the detection capabilities of the array for small signal-to-noise ratio events with frequencies above 0.3 Hz.

<table>
<tr><td colspan="3">Report Documentation Page</td><td colspan="2">Form Approved
OMB No. 0704-0188</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>1. REPORT DATE
SEP 2000</td><td colspan="2">2. REPORT TYPE</td><td colspan="2">3. DATES COVERED
00-00-2000 to 00-00-2000</td></tr>
<tr><td colspan="3" rowspan="3">4. TITLE AND SUBTITLE
Installation And Pre-Certification Of CTBT Station IS59, Hawaii</td><td colspan="2">5a. CONTRACT NUMBER</td></tr>
<tr><td colspan="2">5b. GRANT NUMBER</td></tr>
<tr><td colspan="2">5c. PROGRAM ELEMENT NUMBER</td></tr>
<tr><td colspan="3" rowspan="3">6. AUTHOR(S)</td><td colspan="2">5d. PROJECT NUMBER</td></tr>
<tr><td colspan="2">5e. TASK NUMBER</td></tr>
<tr><td colspan="2">5f. WORK UNIT NUMBER</td></tr>
<tr><td colspan="3">7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Hawaii, Manoa,Infrasound Laboratory,2500 Campus Road ,Honolulu,HI,96822</td><td colspan="2">8. PERFORMING ORGANIZATION REPORT NUMBER</td></tr>
<tr><td colspan="3" rowspan="2">9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</td><td colspan="2">10. SPONSOR/MONITOR’S ACRONYM(S)</td></tr>
<tr><td colspan="2">11. SPONSOR/MONITOR’S REPORT NUMBER(S)</td></tr>
<tr><td colspan="5">12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited</td></tr>
<tr><td colspan="5">13. SUPPLEMENTARY NOTES
Proceedings of the 22nd Annual DoD/DOE Seismic Research Symposium: Planning for Verification of and Compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) held in New Orleans, Louisiana on September 13-15, 2000, U.S. Government or Federal Rights.</td></tr>
<tr><td colspan="5">14. ABSTRACT
See Report</td></tr>
<tr><td colspan="5">15. SUBJECT TERMS</td></tr>
<tr><td colspan="3">16. SECURITY CLASSIFICATION OF:</td><td rowspan="2">17. LIMITATION OF ABSTRACT
Same as Report (SAR)</td><td rowspan="2">18. NUMBER OF PAGES
10</td><td rowspan="2">19a. NAME OF RESPONSIBLE PERSON</td></tr>
<tr><td>a. REPORT
unclassified</td><td>b. ABSTRACT
unclassified</td><td>c. THIS PAGE
unclassified</td></tr>
</table>

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Equipment and Installation

The equipment installed at IS59 is shown in Figure 3. The digitizer is the Science Horizons, Inc. (SHI) single-channel Analogue Input Module 24-bit Slimline (AIM24S-1), with the attached sealed Authentication box AIMA. Each of the four elements elements has a GPS time stamp and is connected via cable modems to a multidrop box, which ties in to a FreeWave 900 MHz spread-spectrum radio. A meteorological Handar station is connected to a separate but parallel telemetry line, also with a FreeWave. The two telemetry channels are brought into a 2-port Communications Interface Module (CIM II, bottom black box in Figure 4), which forwards the data to a Remote Processing Computer (RPC, upper black box). The RPC can assemble and forward CD-1 frames to three IP addresses, and also sends the data to the Science Horizons Acquisition and Viewing Executive (XAVE) software package (screen in Figure 4) which archives the data in CSS format and is used to display the real-time data stream. The RPC and XAVE software runs on separate Sun Ultra 5 machines running under the Solaris 7 OS and connected through an ethernet hub. AutoDRM commands are hardware-signed by a Spyrus box with a PC card. All mission-critical systems at the ISLA have Best Power Ferrus Series UPS for backup power.

To protect the equipment against falling hardwood trees, each sensor, AIM, and AIMA are housed inside a concrete vault with 6''' walls and steel lids (Figure 5). A levering system was developed to allow a single person to lift the heavy steel lids. Each site is fenced to discourage visits from pigs, cows, goats, and sheep. Each fence gate and vault is locked. The vaults of the corner elements have internal dimensions of 3'x3', and the central element and the battery vault have dimensions of 4'x4' (Figure 6). The vault of the central element has additional space for the deployment of other equipment.

Power to all elements is provided by a central solar panel array (Figure 7), with a battery bank that will provide backup power for 14 days. The solar panels provide 48 V DC, which is dropped down to 12 V and regulated at each vault. Barbed wire surrounds the battery vault for added security. All elements are connected for power and communications through ground cables. The power cables terminate at the battery vault, and the communication cables terminate at the fenced antenna enclosure, which also contains the Handar meteorological station (Figure 8). A 120' crank-up aluminum tower rises two 10dB Yagis above the rainforest treeline. The Yagis shoot directly to a smaller mast on the roof of the ISLA.

At the time of this writing, two tasks remained unfinished: the construction of the wind-noise-reducing filters and the completion of the VSAT installation. By the time of this publication, both tasks will be completed. The proposed wind-noise reducing filter is a variation of the French star design, but with the addition of more ports. As shown in Figure 9, 120 ports will be deployed in a symmetric 18m diameter array configuration. The central summing manifold is encased in the concrete foundation of the vault, and each port and central manifold intake will have mechanical valves which may be closed for calibration tests and for investigating the response of the pipe arrays.

Access to the conservation/agricultural district that contains the array site is regulated by the landowner through a series of locked gates and by a permit request procedure. No hunting is allowed in the area, and no problems with vandalism have been encountered to date. The ISLA is contained within a fenced facility that is closed and patrolled after work hours. The room that will contain the RPC and XAVE computers as well as the GCI hub will have restricted access and an alarm system. Backup generator power will be enabled after 20 minutes of a major AC power shutdown. However, all mission critical systems for IS59 have at least 1 hour of UPS backup.

Infrasonic Array Data

Array data has been archived since May 26, 2000, and regional and distant events have been observed. Figure 10 shows the channels recorded by IS59. The Chaparral pressure data is sampled at 20 Hz and all auxiliary, SOH, and met data is sampled at 1 Hz. Regional infrasonic events are generated by the slamming of surf along the cliffs, airplanes taking off and landing (Figure 11), and man-made explosions. The archived CSS data is post-processed using Matseis. In Figure 11, moving from top to bottom, the upper four waveforms (I59HxBDO) show the raw data, with a bandpass of approximately 0.01-8 Hz. The next four waveforms (I59HxBDObp) are band-passed filtered (two-pole, zero-phase Butterworth window) between 0.1-1 Hz, where microbarom signals dominate. The next four waveforms (I59HxBDOhp) are high-passed filtered for frequencies above 1 Hz. The last trace is an STA/LTA filter on I59H4BDOhp, with STA = 1 and LTA = 100. This signal can be clearly seen even in the raw data. The FK analysis for the band-passed signal contained within the dashed lines in the upper panel of Figure 11 is shown in the lower left panel. The arrival azimuth of 325^{o} apparent phase velocity of 360 m/s across the array suggests that this signal originated from an aircraft departing from the Kona airport, at a range of ~20 km. Later arrivals (Figure 11, lower right hand panel) have smaller amplitudes and higher frequencies, and are more typical of

the aircraft signals observed by IS59. However, sometimes the aircraft signals are not detected, suggesting that these arrivals may be dependent on the boundary layer conditions. Because the airstrip is aligned in the N-S direction and the predominant winds are in the E-W direction, the takeoff and landing direction may be varied throughout the day according to the predominant wind component along the N-S direction. Accordingly, aircraft signals may appear either slightly North or South of the airport.

In contrast to the MB2000, the Chaparral 5 sensors appear to be fairly insensitive to seismic events and may be tuned to have very low self-noise levels. Acoustic events that were not observed during the site survey (utilizing the MB2000) are now routinely observed by the Chaparrals, and similarly, seismic events are seldom observed. Some discrete events appear to come from distant sources because they exhibit dispersion. Positive identification of unknown distant sources is difficult without another array. However, various microbarom signals can be associated with well-defined storm systems in the Pacific Ocean, such as Typhoon Kirogi in Japan (Garcés et al., 2000).

CONCLUSIONS AND RECOMMENDATIONS

IS59 is operational, and efforts are under way to complete the installation so as to comply with the CTBT certification standards. IS59 is recording various intriguing signals that are difficult to identify and locate. Some of our event identification problems may be alleviated as the other IMS infrasound arrays are deployed and as other sources of data are integrated in the analysis. However, regional events may be difficult to identify and locate without an additional array on the island. It may be possible to enhance the array's ability to locate events by including seismic data in the analysis, although this improvement would be limited earthquake identification and to the analysis of acoustic signals that couple well into the ground. An additional limitation is the significant spatial aliasing above ~0.3 Hz induced by the 1.9 km aperture of the array. For these higher frequencies, our array processing capabilities are restricted to signals with a large signal-to-noise ratio. The aliasing problem can be solved by the addition of three elements near the center of the array.

REFERENCES

Garcés, M., and H. Bass (1999). *Results of the infrasonic site survey for CTBT station IS59, Hawaii*. Proceedings of the 21st Annual Research Symposium on Monitoring a Comprehensive Test Ban Treaty.

Garcés, M, D. Drob, M. Picone, K. Lindquist, and R. Hansen (2000). *Characterization Of Infrasonic Waves Observed In Hawaii During Summer.* 22nd Seismic Research Symposium: Planning for Verification of and Compliance with The Comprehensive Nuclear-Test-Ban Treaty, New Orleans (this issue).

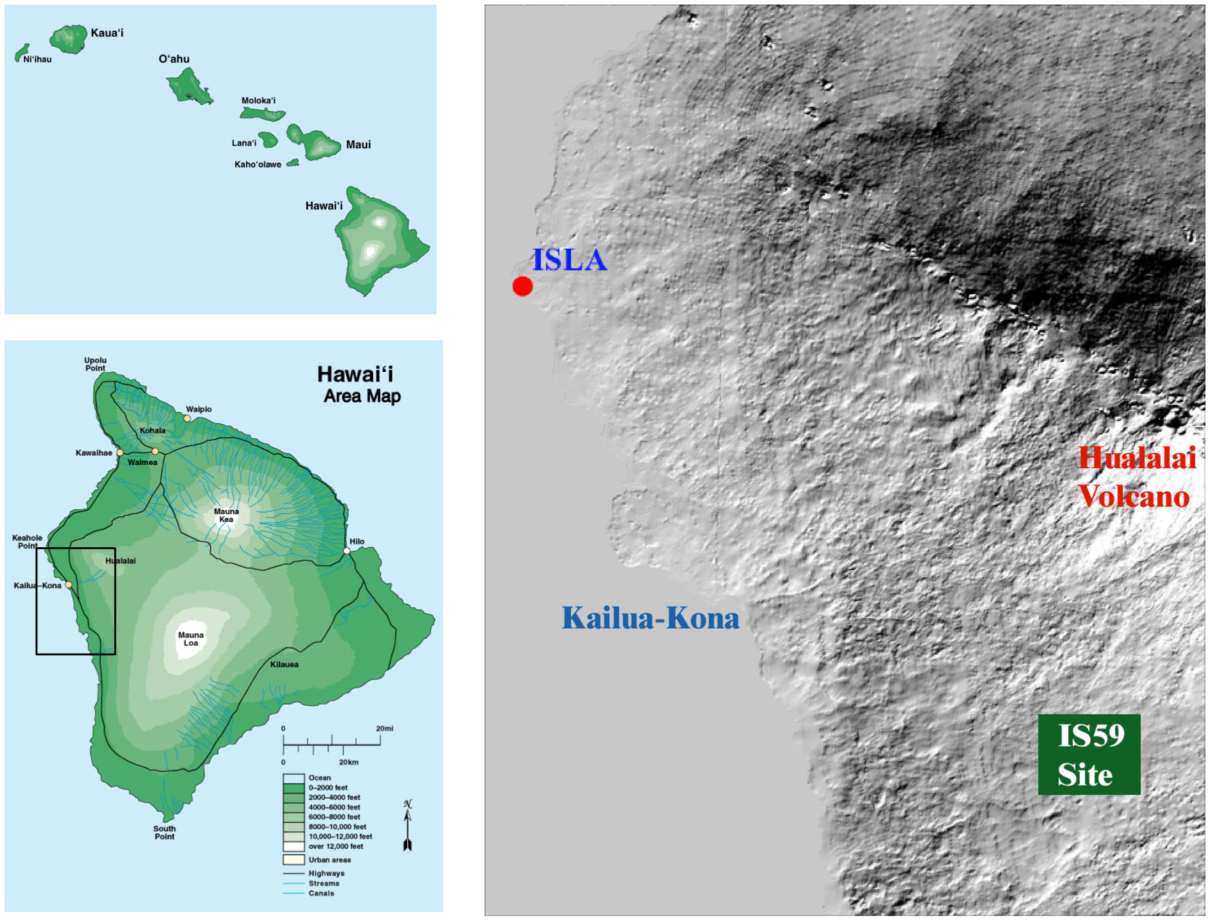

Figure 1. Location of IS59 and Infrasound Laboratory (ISLA) on the island of Hawaii.

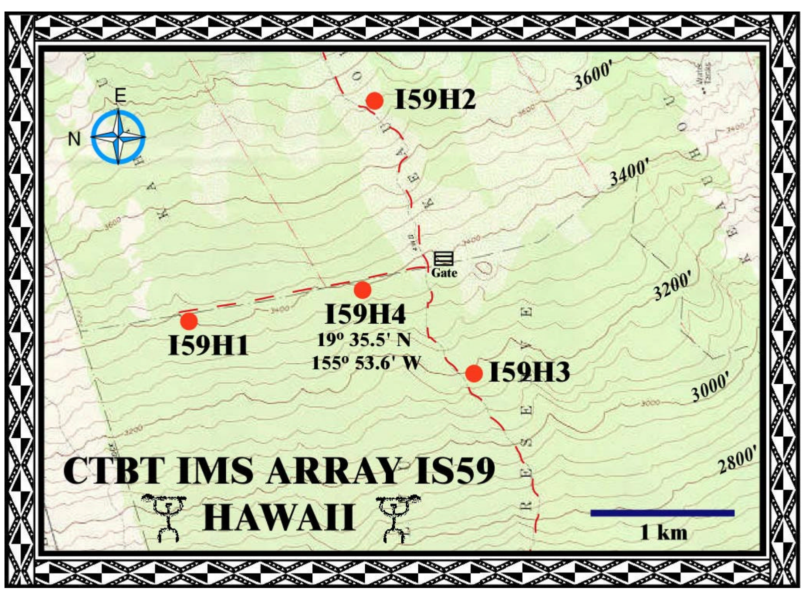

Figure 2. Infrasonic array geometry.

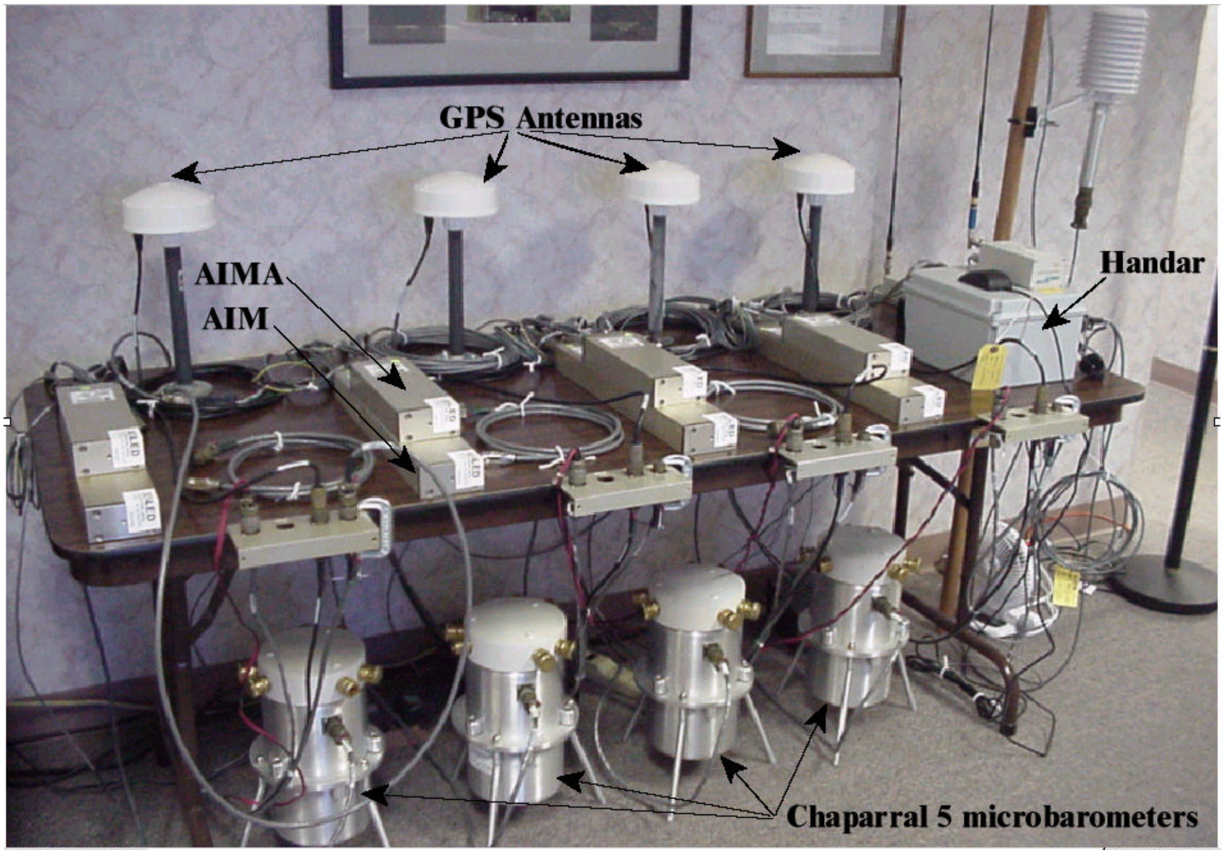

Figure 3. Data acquisition hardware.

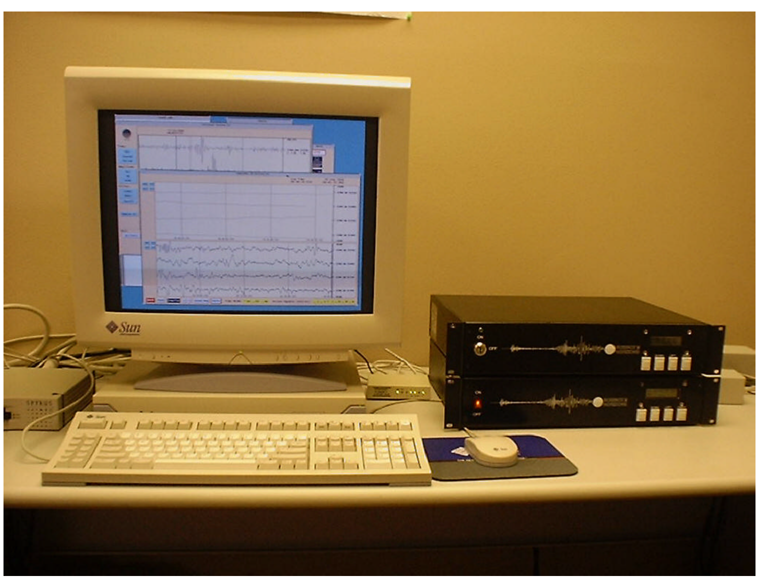

Figure 4. Real-time data manager. The Xave workstation is shown on the left, and the RPC (top) and CIM (bottom) are shown on the left.

Figure 5. Instrument vaults. Six-inch concrete walls and steel lids ensure the equipment's survival in the case of a tree fall. Each vault is locked. Pipes for connecting the wind-noise reducing filters are connected to a summing manifold imbedded in the vault's foundation.

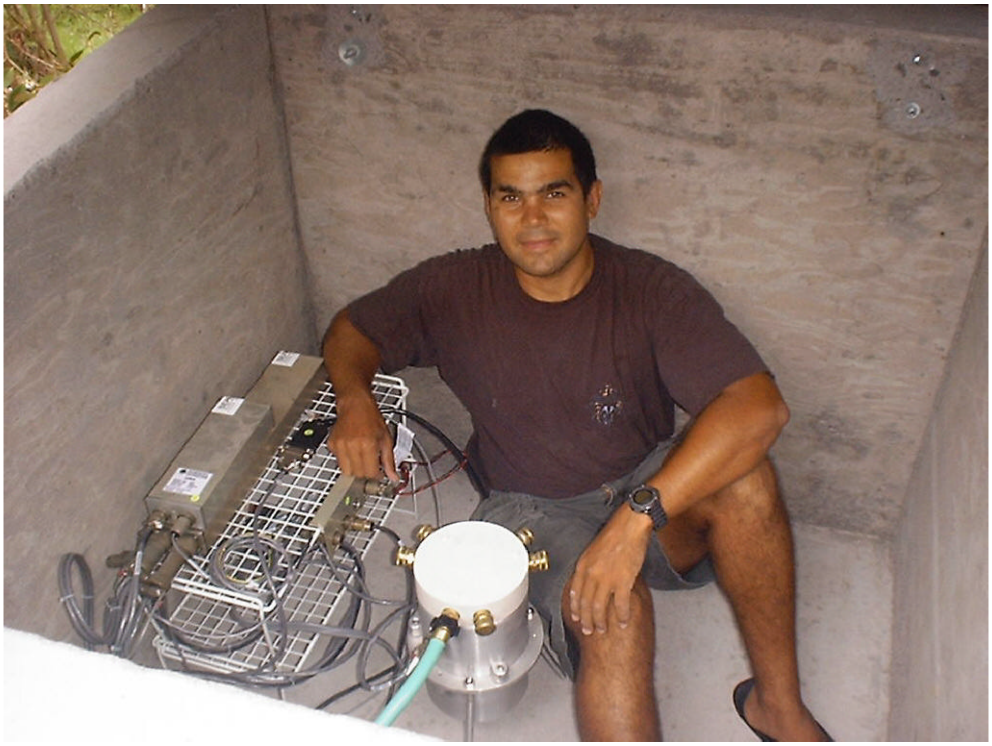

Figure 6. Vault's interior.

Figure 7. Central photovoltaic power system.

Figure 8. Weather station at antenna site.

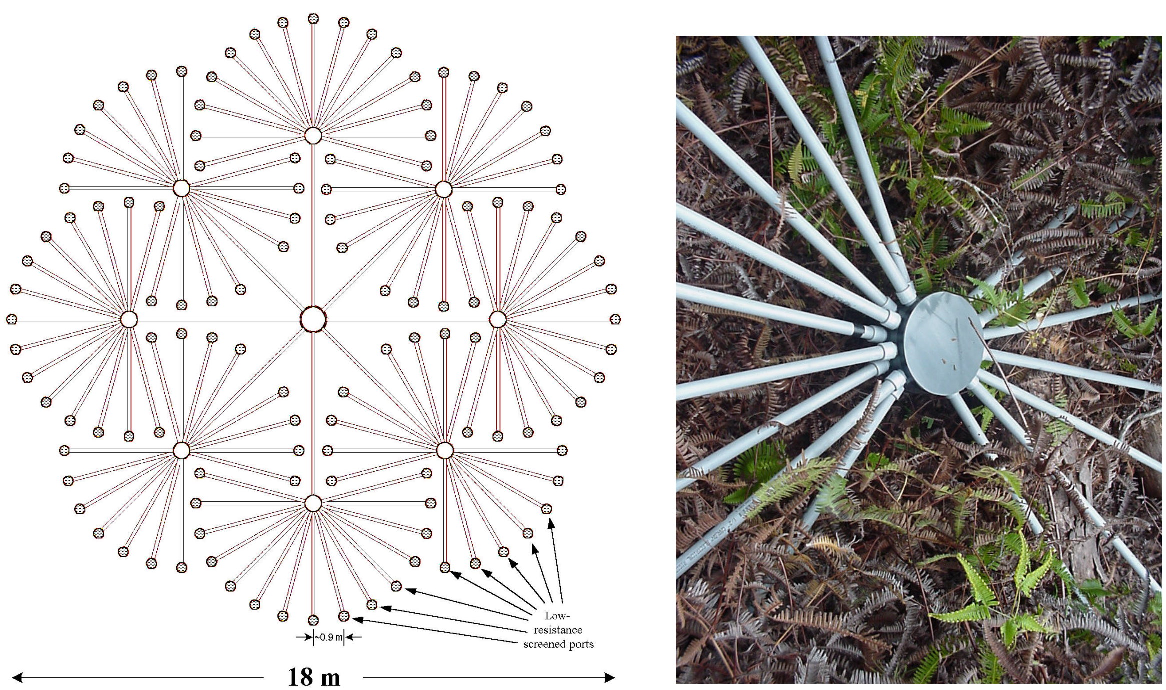

Figure 9. Wind-noise-reducing pipe array design (left) and PVC implementation (right).

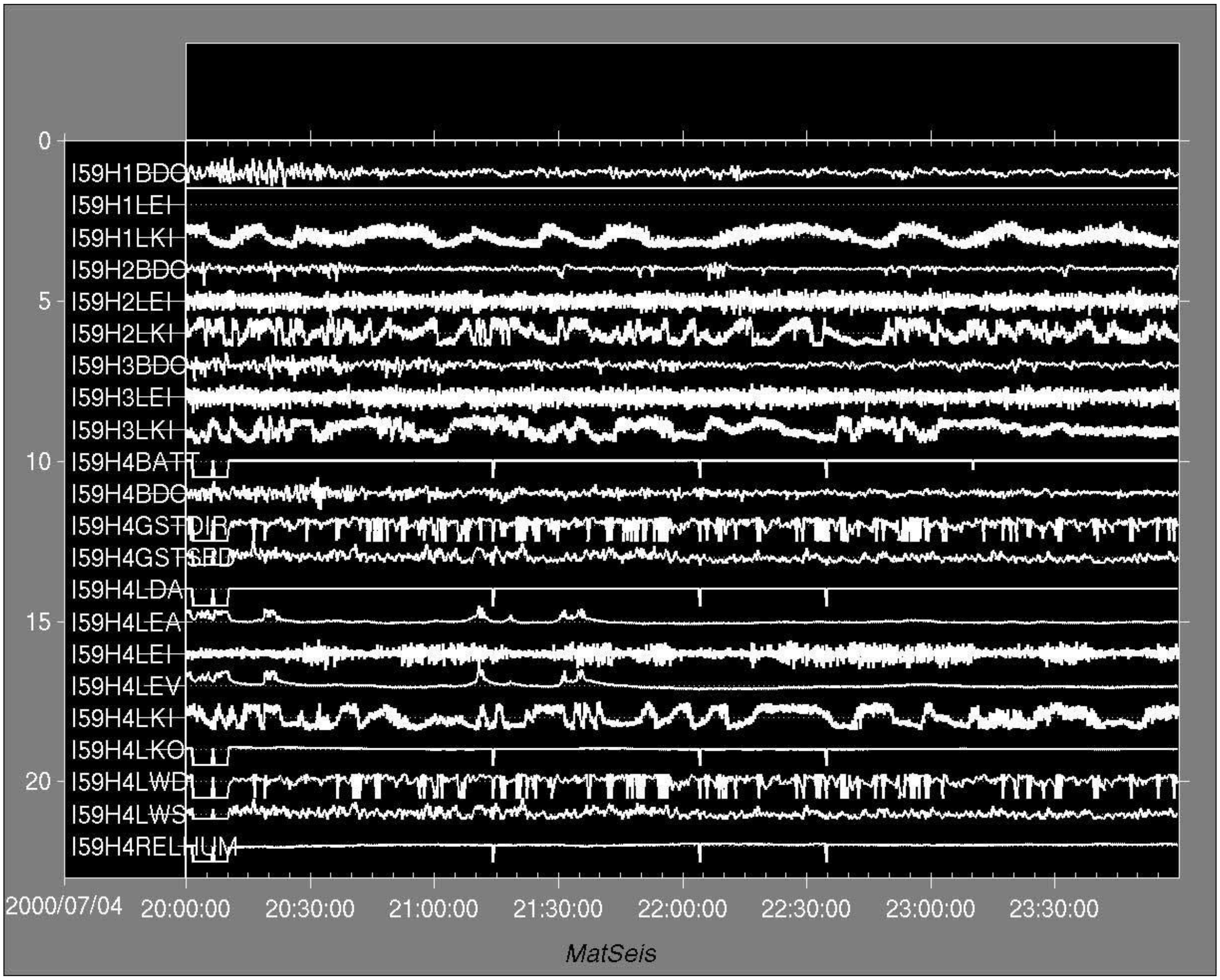

Figure 10. Pressure, meteorological, and state-of-health (SOH) channel data for IS59. All digitizers (IS59H1-4, as shown in Figure 2) have the Chaparral 5 pressure data (BDO, sampled at 20Hz) and two SOH channels sampled at 1 Hz: LEI is the voltage to the digitizer inside the vault, and LKI is the vault temperature. Associated with IS59H4 (central element) are two additional auxiliary channels and the all the Handar meteorological station channels. All of these additional channels are sampled at 1 Hz. LEA is the current and LEV is the voltage at the solar panel battery vault, which provides the power to the array. These two channels are connected as auxiliary channels to the AIM of H4. For the met station, BATT is the battery voltage, GSTDIR is the wind gust direction, GSTSPD is the wind gust speed, LDA is the barometric pressure, LKO is the outside temperature, LWD is the wind direction, LWS is the wind speed, and RELHUM is the relative humidity. The met station and digitizer data are telemetered on separate but parallel radio links to ISLA, where all data is assembled into CD-1 frames. The pressure channel will be renamed to BFO and I59H4 will be renamed I59H0, but at the time of this writing these changes have not been implemented.

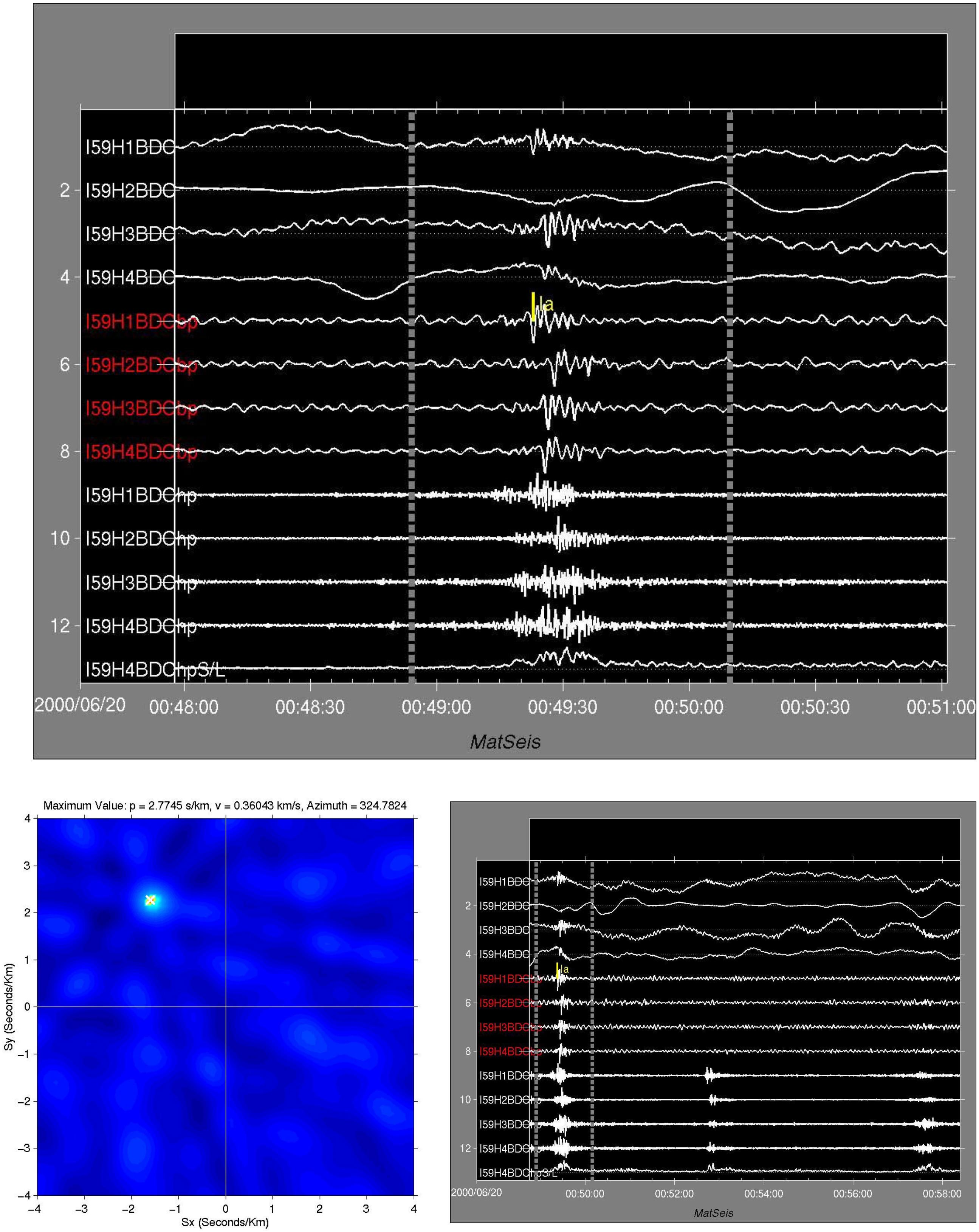

Figure 11. Pressure signal originating from the direction of the Kona International Airport.